

Introduction

During digital data transmission, all members of the communication network must transmit and receive at the same frequency to minimize data loss and error. To attain a satisfactory level of accuracy, Meridian 1 systems use Clock Controllers to synchronize operations.

This document discusses Clock Controllers, focusing on installation and replacement procedures. This introduction provides background information about the purpose and function of Clock Controllers for readers who may be unfamiliar with the devices.

Clock Controllers commonly work in conjunction with the Digital Trunk Interface (DTI) and Primary Rate Interface (PRI) cards. The dual-CPU systems (NT, XT, XN, options 61, 71, 81, and 81C) are shipped with two Clock Controllers (one Clock Controller for each CPU). Single CPUs also require a Clock Controller when DTI or PRI is configured.

Analog applications do not require a Clock Controller.

Defining the Clock Controller

Clock Controllers synchronize the system clock rate with the clock rates of digital switching and transmission equipment over a T1 circuit. Dual-CPU systems have two Clock Controllers: CC0 (associated with CPU 0) and CC1 (associated with CPU 1). One Clock Controller is the primary and the other is a backup.

The standard Meridian 1 Clock Controller is the **QPC471**, currently available in vintages C, D, E, F, G, and H. The option 81 and option 81C systems must use vintage H.

Customers outside the United States can use the **QPC775**. Vintage A of the QPC775 can be used with nonnetworked systems (systems linked directly to a central office); vintage B is appropriate for networked systems (Meridian 1 to Meridian 1 configurations). Customers with option 81 or option 81C systems must use QPC775 vintage C.

Note: A system cannot use both the QPC471 and the QPC775. A system can mix Clock Controller vintages A through G. A vintage H Clock Controller can be used only with another vintage H Clock Controller.

Why networks use Clock Controllers

Both ends of a digital communication link must operate at the same data rate. If link synchronization is not established, data bit slips can occur resulting in a loss of data. Synchronized timing is essential for reliable digital data transfer.

Synchronization methods

When two Meridian 1 switches are connected to one another, one system can derive its timing from the other in a master/slave mode. In a larger network, the digital systems must use one of two synchronization methods:

- Nodal clocks can run independently at the same nominal frequency. Frequency differences among clocks result in frame slips, although the number and magnitude of slips can be minimized by using stable clocks and dynamic buffers that can absorb a limited number of data bits.
- Nodal clocks can be automatically locked to an external reference clock: the central office (CO) or another Meridian 1. This method is recommended; it eliminates frame slips if dynamic buffers are large enough to compensate for transmission variances.

Hierarchical synchronization

The primary timing reference in North America is based on a cesium beam atomic clock. The digital network in the United States, for example, is divided into two regions (one in St. Louis, the other in Boulder, Colorado), each with its own cesium atomic clock. Any DS-1 signal leaving these switches is synchronized to the cesium oscillators. Every digital node should be linked to one of the cesium atomic clocks.

In the North America digital network, a priority master/slave method is the basis for node synchronization. The telecommunications industry in the United States adheres to a four-level categorization: stratum 1, stratum 2, stratum 3, and stratum 4. The Canadian node category A is equivalent to the U.S. stratum 1 (the Canadian cesium clocks are located in Calgary and Ottawa); categories B and C are equivalent to stratum 2; category D is equivalent to stratum 3; and category E is equivalent to stratum 4.

- Stratum 1, the atomic standard, provides the highest level of accuracy.
- Stratum 2 clocks are typically used in large digital switching systems, such as a toll office.
- Stratum 3 clocks help synchronize CO and PBX operations. The Meridian 1 Clock Controllers adhere to this standard.
- Stratum 4 clocks are the least accurate.

Table 1 shows the parameters required for nodes that conform to each stratum.

Table 1
Node accuracy and parameters

	Stratum 2	Stratum 3	Stratum 4
Accuracy	$\pm 1.6 \times 10^{-8}$ Hz	$\pm 4.6 \times 10^{-6}$ Hz	$\pm 3.2 \times 10^{-5}$ Hz
Holdover	1×10^{-10} per day	≤ 255 frame slips in first 24 hours	Not required
Hardware duplication	Required	Required; nonduplicated clock hardware that meets other stratum 3 requirements is referred to as stratum 3ND.	Not required
MTIE during rearrangement	MTIE ≤ 1 μ sec Phase Change Slope: ≤ 81 ns in any 1.326 msec	MTIE ≤ 1 μ sec Phase Change Slope: ≤ 81 ns in any 1.326 msec	Not required; stratum 4 hardware that meets MTIE requirements during rearrangements is referred to as 4E
Pull-in range	3.2×10^{-8} Hz	9.2×10^{-6} Hz	6.4×10^{-5} Hz
Dedicated timing required	Required	Required	Not required

When the Meridian is used in a hierarchical digital network, each clock accepts synchronization from the external master clock designated as a higher-level source. The individual clocks help synchronize lower-level clocks. If the network connection fails, clocks receive synchronization signals from the highest available source.

Frame slip

A *frame slip* is the repetition or deletion of the 193 data bits of a DS-1 frame and results from a discrepancy between buffer read and write rates. When data bits write to the buffer faster than they are being read, the buffer overflows: this is a slip-frame deletion. When data bits are read faster than they are written, the buffer runs dry: this is a slip-frame repetition.

Slippage can affect data as follows:

- encrypted text: encryption key must be present
- video: freeze frame for several seconds; loud pop on audio
- digital data: deletion or repetition of data; possible misframe
- facsimile: deletion of 4–8 scan lines; drop call
- voice band data: transmission errors for 0.01 to 2 seconds; drop call
- voice: possible click

Determining network configuration

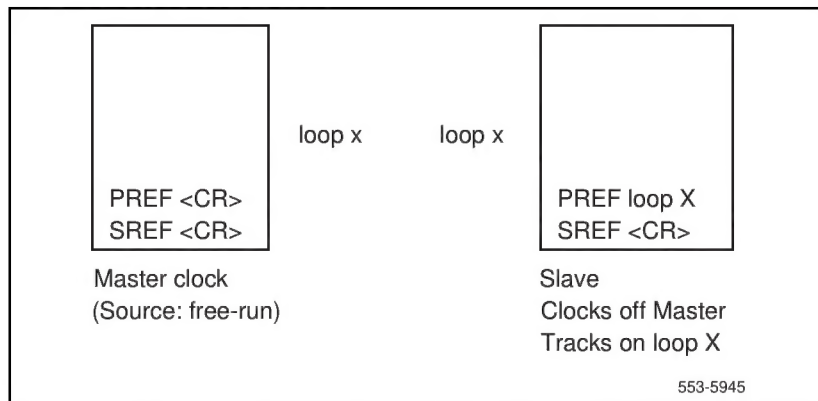
In a master/slave network, the master clock should be the highest stratum clock. If there is more than one clock at this level, the clock with the most connections to other clocks should be the master. If two or more clocks have the same number of connections, the most reliable clock should be the master.

The configuration should avoid timing loops, which occur when a clock uses a signal that can be traced to the output of that clock. Closed timing loops on the primary clock are not permitted as they lead to frequency instability. Timing loops are sometimes unavoidable on the secondary clock reference source.

All central office/system links used as clock references should be traceable to the same stratum 1 clock source.

The most common network configuration uses a master Clock Controller that synchronizes the other (slave) Clock Controllers. The master can link directly to all the slaves, or it can be associated with them in a hierarchical relationship. **Figure 1** shows an example of a simple master/slave operation.

Figure 1
Master/slave relationship



For tie lines between systems connected to a central office, the system, not the CO, establishes the clocking.

As **Figure 2** shows, when a secondary digital loop is available, it can be used as a secondary clock source if the primary source fails.

Figure 2
Master/slave with a secondary clock source

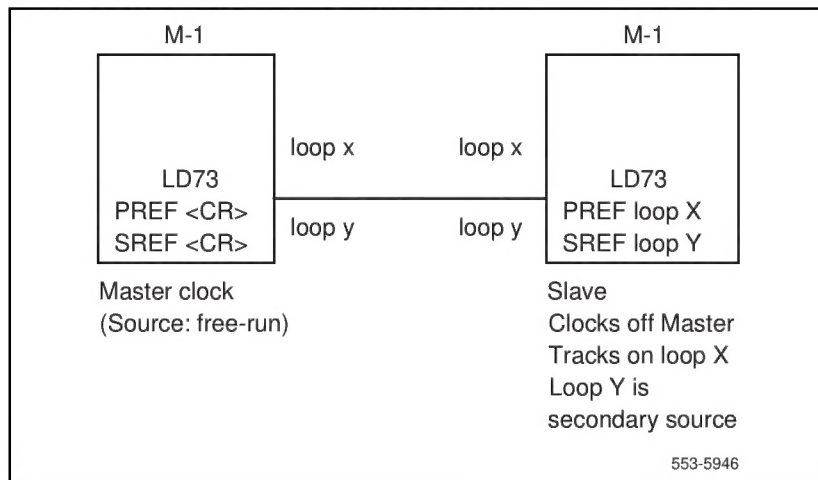
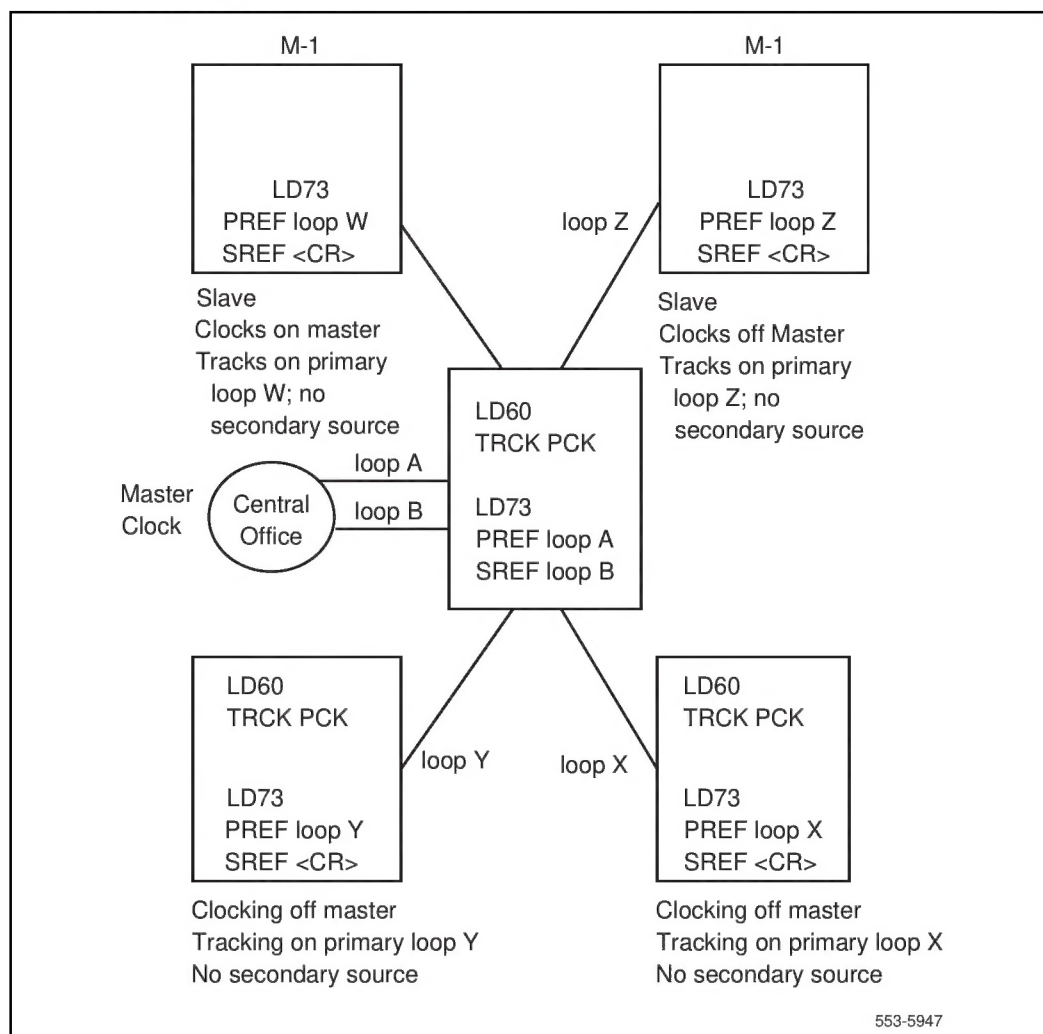


Figure 3 shows a star arrangement: one hub system is linked to the central office. All other systems are connected as slaves. If a second system digital loop from the hub system is available, it can be used as a secondary clock source if the primary source fails.

Figure 3
Star clocking arrangement



A small network can use a mutual synchronization structure, in which all members can receive synchronization signals from the others.

In another configuration, systems operate independently, each clocking off its own central office master clock. The systems use loops that interconnect them as secondary clocking sources. In this configuration, all central offices must have a path to the same stratum 1 source.

The previous figures indicate the LD 60 and LD 73 software commands required to set up the system. For more information, see “Clock Controller commands” on page 19.

Other documents

Refer to the following documents to learn more about the systems environment for Clock Controllers:

- *Digital Trunk Interface/Computer-to-PBX Interface installation and data administration* (553-2811-200)
- *ISDN Primary Rate Interface installation* (553-2901-200)
- *X11 input/output guide* (553-3001-400)